Chapter 3 : Air Quality Analysis

Synopsis

This chapter describes the approach used to calculate 2020 baseline SO_2 design values and the amount of emissions reductions needed to attain the alternative 1-hour SO_2 NAAQS. The NAAQS being analyzed are 50, 75, 100, and 150 ppb based on design values calculated using the 3-year average of the 98th and 99th percentile 1-hour daily maximum concentrations based on the monitoring network described in Chapter 2. The projected 2020 baseline SO_2 design values are used to identify 2020 nonattainment counties and to calculate, for each such county, the amount of reduction in SO_2 concentration necessary to attain the alternative NAAQS. This chapter also describes the approach for calculating "ppb SO_2 concentration per ton SO_2 emissions" ratios that are used to estimate the amount of SO_2 emissions reductions that may be needed to provide for attainment of the alternative SO_2 standards. As described below, the air quality analysis relies on SO_2 emissions from simulations of the Community Multiscale Air Quality (CMAQ) model coupled with ambient 2005-2007 design values and emissions data to project 2020 SO_2 design value concentrations and the "ppb per ton" ratios. A description of CMAQ is provided in the Ozone NAAQS RIA Air Quality Modeling Platform Document (EPA, 2008a).

3.1 2005-2007 Design Values

The proposed standard is based on the 3-year average of the 98th or 99th percentile concentration of the daily 1-hour maximum concentration for a year. The design value for each percentile is calculated as:

- Identify daily 1-hour maximum concentration for each day for each year
- Calculate 98th and 99th percentile values of the daily 1-hour maximum concentrations for each year
- Average the 98th percentile values for the three years. Average the 99th percentile values for the three years.

Monitors that had valid measurements for at least 75% of the day, 75% of the days in a quarter and all 4 quarters for all three years were included in the analysis[1]. The resulting 3-year averaged 98th and 99th percentile daily 1-hour maximum concentrations are shown in Figures 3.1 and 3.2 respectively for 229 monitored counties. Counties in blue, green, yellow, and scarlet would exceed the lowest alternative standard considered in the RIA, 50 ppb. The

[1] Email from Rhonda Thompson to James Thurman, January 22, 2009.

counties are color-coded based on the alternative standards; i.e. counties in green exceed 75 ppb but not 50 ppb. Monitors with design values of 50.0 to 50.4 ppb would not exceed the standard 50 ppb as those concentrations would round to 50 ppb. Concentrations 50.5 ppb and higher are considered exceeding the lowest alternative standard. Similar rounding is done for the 75, 100, and 150 ppb alternative standards (75.4, 100.4, and 150.4 are the cut-offs for nonattainment). A summary of the number of counties exceeding the alternative standards for 2005-2007 is shown in Table 3.1. Appendix 3 contains the complete list of 2005-2007 design values used in calculation of the 2020 design values. Table 3.2 lists the top ten counties for the 99th percentile design values for 2005-2007.

Figure 3.1. 2005-2007 3-year averaged design values (ppb) for 98th percentile daily 1-hour maximum SO_2 concentrations. Values shown are county maxima.

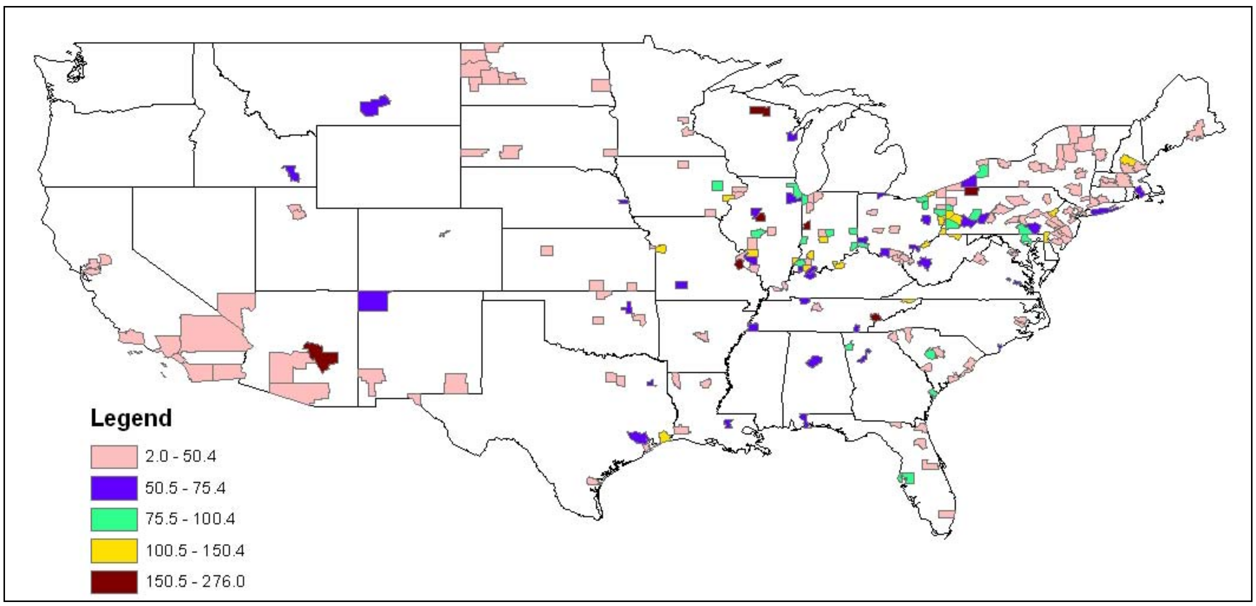


Figure 3.2. 2005-2007 3-year averaged design values (ppb) for 99th percentile daily 1-hour maximum SO_2 concentrations. Values shown are county maxima.

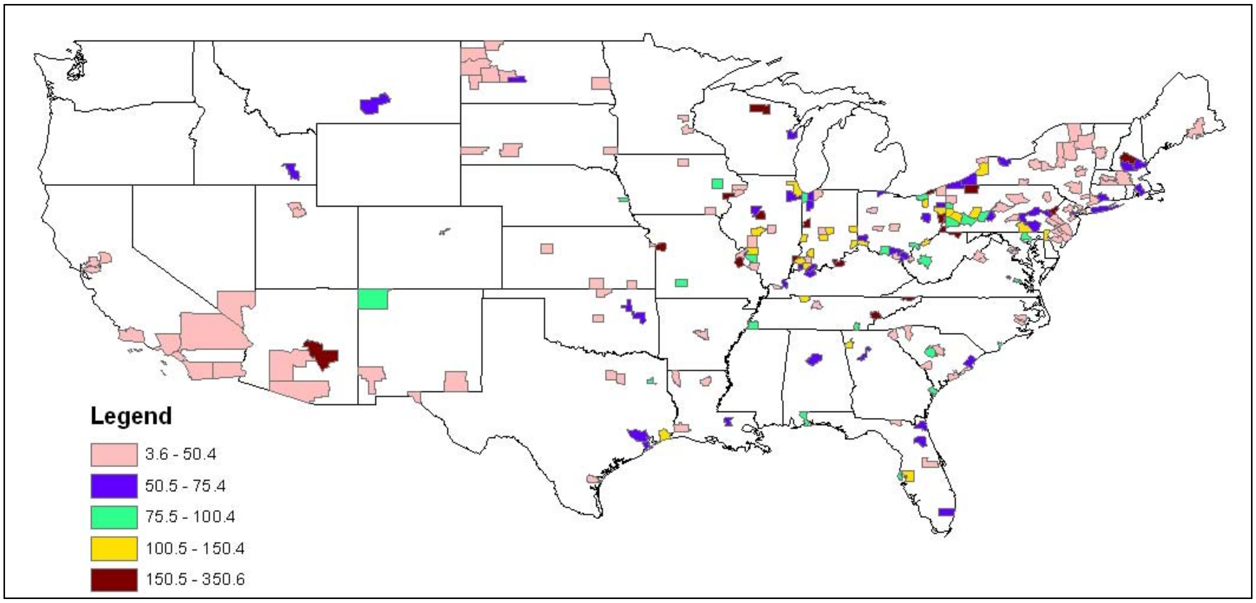


Table 3.1. Number of monitors and counties exceeding 50, 75, 100, and 150 ppb alternative standards for 98th and 99th percentile design values for 2005-07.

Alternative standard (ppb)	Percentile	Number of monitors	Number of counties
50	98th	132	93
	99th	169	119
75	98th	69	54
	99th	95	70
100	98th	41	39
	99th	59	46
150	98th	7	7
	99th	23	21

Table 3.2. Top 10 2005-07 counties 99th percentile design values.

State	County	Design value (ppb)
MO	Jefferson	350.6
AZ	Gila	286.0
IL	Tazewell	222.3
PA	Warren	214.0
TN	Blount	196.3
PA	Northampton	187.0
IN	Fountain	183.0
OH	Lake	180.3
WI	Oneida	179.0
IN	Floyd	176.3

3.2 Calculation of 2020 Projected Design Values

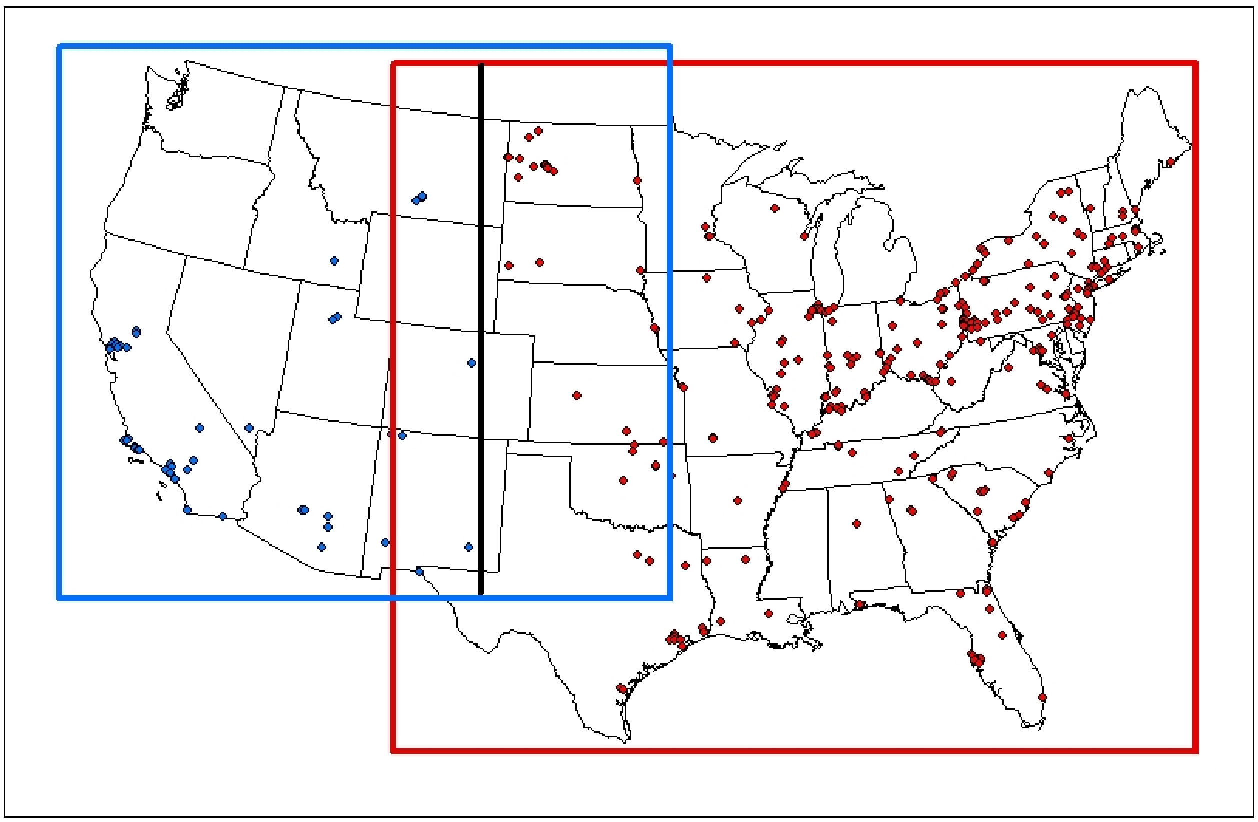
The 2020 baseline design values were determined using CMAQ gridded emissions for 2006 and 2020. Gridded emissions were utilized instead of county emissions because of the influence of stationary sources on SO_2 concentrations. For monitors near county boundaries, stationary sources in a neighboring county may have more influence over the monitor than a stationary source in the monitor's home county. The 2020 emissions were used in CMAQ runs for the ozone RIA (EPA, 2008b). Due to timing and resource issues, we decided to use existing CMAQ inputs for ozone modeling instead of conducting new modeling. The SO_2 emissions in the CMAQ runs reflect reductions from federal programs including the Clean Air Interstate Rule (EPA, 2005a), the Clean Air Mercury Rule (EPA, 2005b), the Clean Air Visibility Rule (EPA, 2005c), the Clean Air Nonroad Diesel Rule (EPA, 2004), the Light-Duty Vehicle Tier 2 Rule (EPA, 1999), the Heavy Duty Diesel Rule (EPA, 2000); proposed rules for Locomotive and Marine Vessels (EPA, 2007a) and for Small Spark-Ignition Engines (EPA, 2007b); and national, state and local level mobile and stationary source controls identified for additional reductions in emissions for the purpose of attaining the current PM 2.5 and Ozone standards. It should be noted that the emission reductions modeled for the PM2.5 and Ozone standards represent one possible control scenario, while the actual control strategies and resulting levels of emission reductions will be determined as part of the process of developing and implementing state implementation plans over the coming years. The 2006 emissions also reflect emissions as part of the Category 3 (engines with 30 liter or more cylinder displacement) marine diesel engine Rule (EPA, 2009).

In brief, these CMAQ emissions were at 12 km horizontal resolution for two modeling domains which, collectively, cover the lower 48 States and adjacent portions of Canada and Mexico. The boundaries of these two domains are shown in Figure 3.3. For 2020 we used CMAQ SO_2 emissions from the Ozone NAAQS RIA "2020_070" control case.

3.2.1 2020 Design Value Calculation Methodology

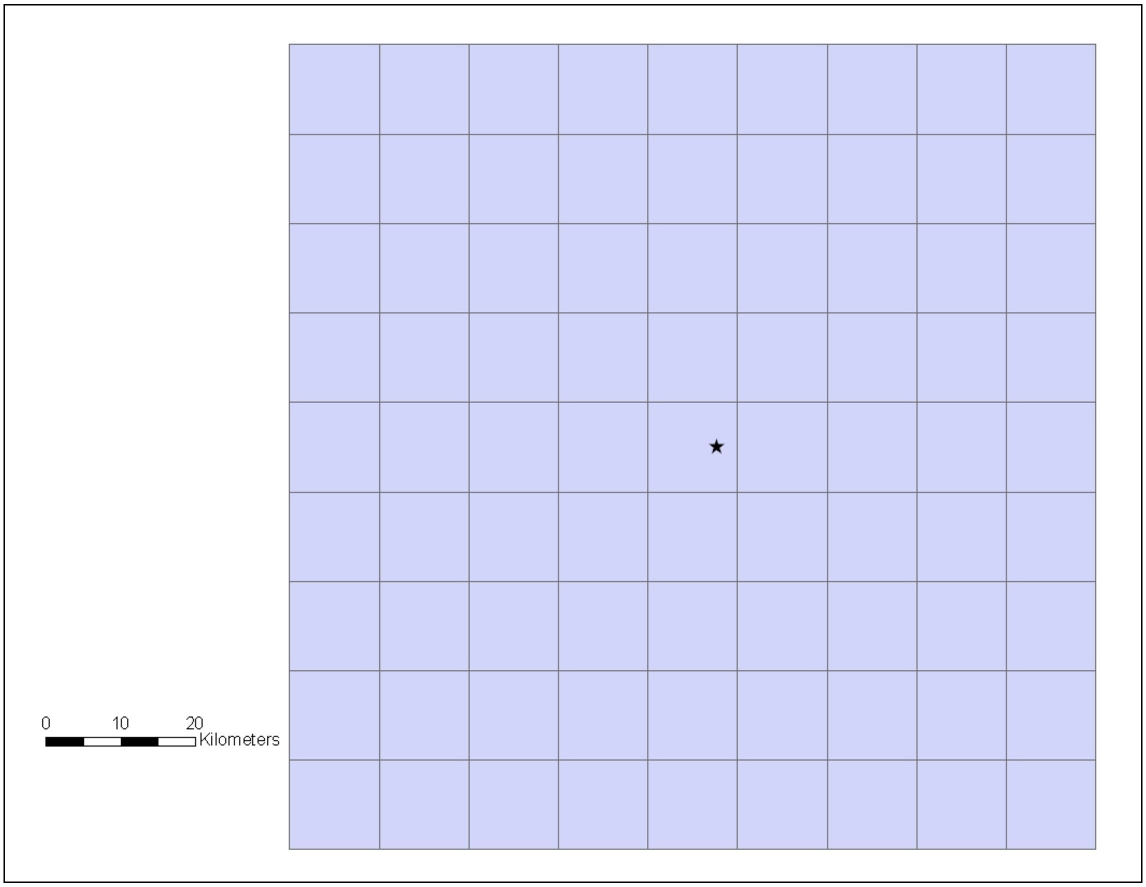
Ambient monitored data were assigned to CMAQ grid cells using ArcGIS. Since there were areas of the country where the eastern and western domains overlapped, monitors in these overlapping areas were assigned to the eastern or western grid cells by using a "combined grid." This combined grid was a mesh of the eastern and western domains, with overlapping areas assigned eastern grid cells or western grid cells based on the location relative to the dividing line shown in Figure 3.3. Figure 3.3 shows the assignment of monitors to the two domains. An example of monitors in both domains was the El Paso County monitors. These monitors were assigned to the western domain. The gridded 2006 and 2020 emissions were also assigned to the combined grid based on the same grid assignments as the monitors.

Figure 3.3. Monitor domain assignments. Western domain is outlined in blue and eastern domain outlined in red. Black vertical line denotes dividing line between eastern and western domains for monitor assignments. Monitors in blue were assigned to the western domain and monitors in red were assigned to the eastern domain.



Once the monitors and emissions were assigned to the combined grid, for each monitor, a 9x9 matrix of grid cells was selected, centered on the monitor. An example is shown in Figure 3.4. The 9x9 matrix represented an approximate domain of emissions extending out 50 km from the monitor, the upper range of near-field dispersion. Since the design values were based on hourly concentrations, extending the radius of influential emissions on the monitor grid cell to 50 km was considered appropriate.

Figure 3.4. 9 x 9 matrix of 12km grid cells centered on CMAQ cell containing an SO_2 monitor (star).



Once the matrices of grid cells were created for each monitor, the 2006 and 2020 gridded emissions were summed separately across the 81 grid cells to result in total 2006 and 2020 emissions for each monitor. The summed 2020 emissions were then divided by the 2006 emissions to get an emissions change ratio:

$$E_{ratio} = \frac{E_{2020}}{E_{2006}} \tag{3.1}$$

Where E_{2020} are the summed 81 grid cell emissions for 2020, E_{2006} are the summed 81 grid cell emissions for 2006 and E_{ratio} is the ratio of 2020 emissions to 2006 emissions.

The 2005-2007 98th and 99th percentile design value concentrations were then multiplied by the emissions ratio to calculate the 2020 design values.

$$DV_{2020"P} = DV_{2005-2007:P} \times E_{ratio} \quad (3.2)$$

Where E_{ratio} is as defined above, $DV_{2005\text{-}2007:P}$ is the 2005-2007 3-year averaged design value for percentile P (98th or 99th), and $DV_{2020:P}$ is the projected 2020 design value for percentile P (98th or 99th).

After calculating the 2020 design values, a ppb/ton estimate was calculated by:

$$ppb/ton_P = {(DV_{20205:P} - DV_{2005-2007:P})} \Big/ {(E_{2020} - E_{2006})} \quad (3.3)$$

Where E_{2020} and E_{2006} are the summed emissions as defined for Equation 3.1, $DV_{2005\text{-}2007:P}$ and $DV_{2020:P}$ are as defined above and ppb/ton_P is the ppb/ton estimate for percentile P (98th or 99th).

Residual nonattainment estimates for the four alternative standards of 50, 75, 100, and 150 ppb were calculated by subtracting the alternative standard from the 2020 design value (98th and 99th percentiles). The absolute values of the alternative standards (50, 75, 100, or 150 ppb) were not subtracted but rather the highest value that would meet the standards (50.4, 75.4, 100.4 and 150.4 ppb) if design values were rounded to the nearest whole ppb. Once residual nonattainment was calculated for each alternative standard, for monitors exceeding the standards, tons needed for control were calculated by dividing residual nonattainment by the ppb/ton estimate:

$$Tons_{P:AS} = \frac{NA_{P:AS}}{ppb/ton_P} \quad (3.4)$$

Where ppb/ton_P is as defined above, $NA_{P:AS}$ is the residual nonattainment for alternative standard AS (50, 75, 100, or 150 ppb) for percentile P (98th or 99th), and $Tons_{P:AS}$ are the tons needed to reach attainment for alternative standard AS for percentile P.

3.3 Results

3.3.1. Nonattainment results

Table 3.3 lists the number of monitors and counties exceeding the four alternative standards for the 98th and 99th percentile 2020 design values. The number of counties exceeding each of the alternative standards decreased from 2005-2007 to 2020. Figures 3.5 and 3.6 show the maximum 2020 design value for monitored counties for the 98th and 99th percentile design values. Counties in blue, green, yellow, and scarlet exceed the 50 ppb alternative standard. Table 3.4 lists the top 10 counties in 2020 for the 99th percentile design value along with residual nonattainment and tons needed for control to meet attainment. A complete list of 2020 design values for all monitors can be found in Appendix 3.

Table 3.3. Number of monitors and counties exceeding 50, 75, 100, and 150 ppb alternative standards for 98th and 99th percentile design values for 2020.

Alternative standard (ppb)	Percentile	Number of monitors	Number of counties
50	98th	43	33
	99th	74	57
75	98th	21	16
	99th	30	24
100	98th	13	11
	99th	17	14
150	98th	5	5
	99th	6	6

Figure 3.5. 2020 design values (ppb) for 98th percentile daily 1-hour maximum SO_2 concentrations. Values shown are county maxima.

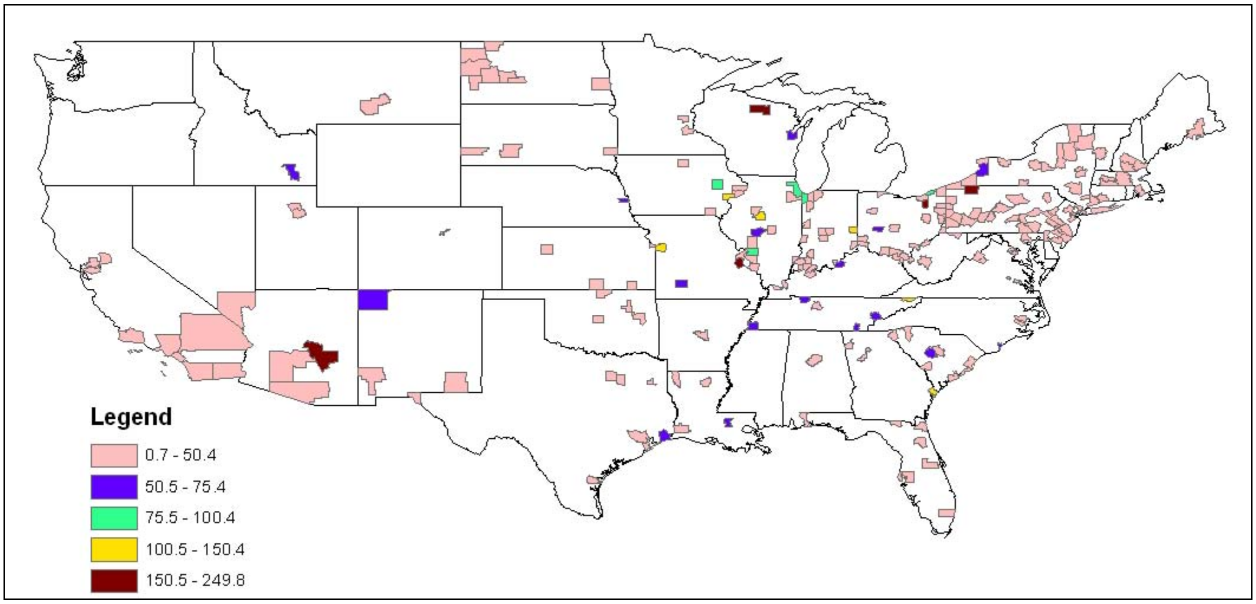


Figure 3.6. 2020 design values (ppb) for 99th percentile daily 1-hour maximum SO_2 concentrations. Values shown are county maxima.

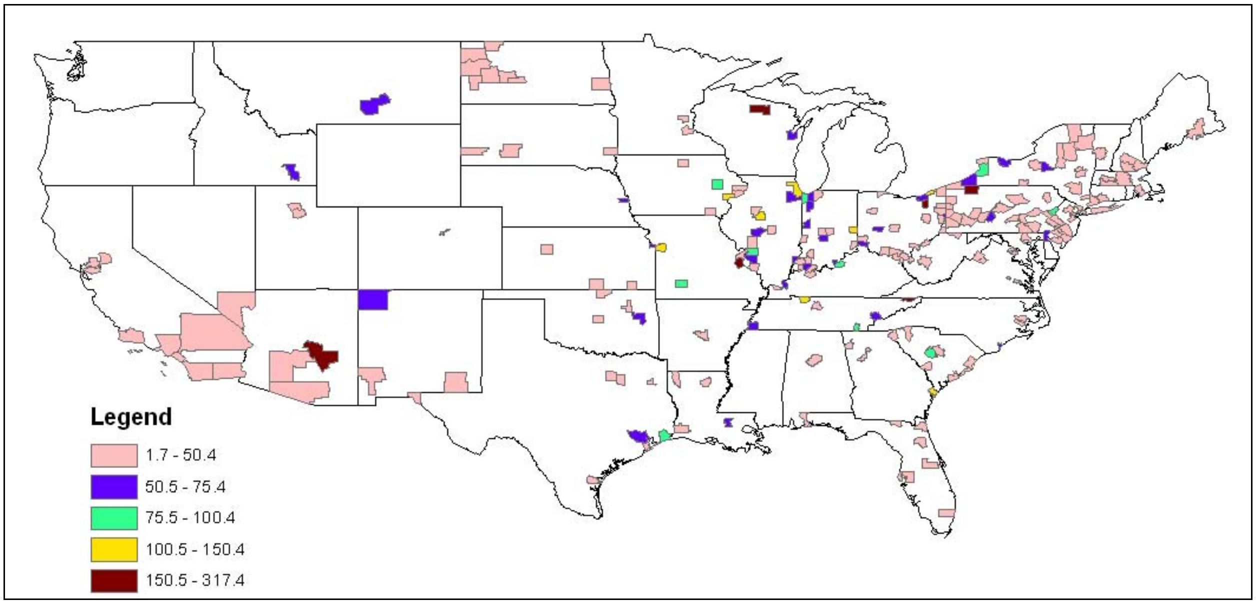


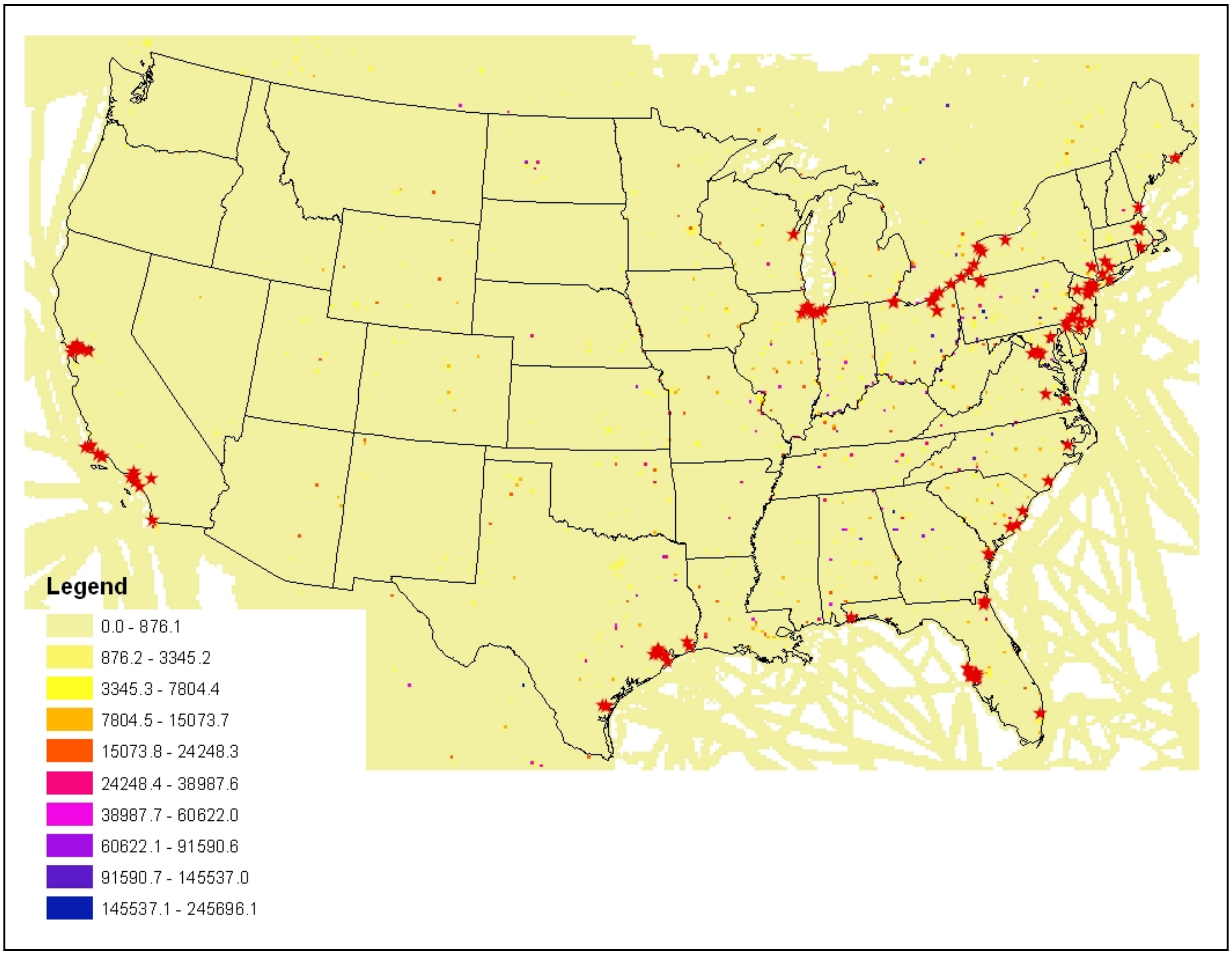
Table 3.4. Top 10 2020 counties 99th percentile design values.

			Alternative standards (ppb)							
			50		75		100		150	
State	County	2020 DV	Residual nonattainment	Tons for control	Residual nonattainment	Tons for control	Residual nonattainment	Tons for control	Residual nonattainment	Tons for control
MO	Jefferson	317.4	267	135,586	242	122,891	217	110,195	167	84,805
AZ	Gila	296.5	246.1	16,193	221.1	14,548	196.1	12,903	146.1	9,613
PA	Warren	245.7	195.3	14,150	170.3	12,338	145.3	10,527	95.3	6,905
WI	Oneida	183.1	132.7	7,427	107.7	6,028	82.7	4,628	32.7	1,830
OH	Summit	170.6	120.2	41,312	95.2	32,720	70.2	24,127	20.2	6,943
TN	Sullivan	169.2	118.8	66,461	93.8	52,475	68.8	38,489	18.8	10,517
IL	Tazewell	149.3	98.9	41,589	73.9	31,076	48.9	20,563	-	-
TN	Montgomery	143	92.6	21,081	67.6	15,390	42.6	9,698	-	-
MO	Jackson	138.5	88.1	44,567	63.1	31,920	38.1	19,273	-	-
GA	Chatham	134.8	84.4	29,929	59.4	21,064	34.4	12,199	-	-

3.3.2 2006 ocean-going vessel emissions

The 2006 inventory contained oceangoing SO_2 emissions as part of the proposed Category 3 marine diesel engine rule (EPA, 2009). These can be seen in Figure 3.7 as lines radiating out from port areas. These emissions were not in the 2020 inventory as used in the final ozone RIA. For monitors affected by the oceangoing vessel emissions, the lack of oceangoing vessel emissions in 2020 could lead to an underestimation of 2020 design values. Of the 349 monitors used in this RIA, approximately 119 monitors, based on visual analysis, contained these oceangoing vessel emissions in their 9x9 matrix of 2006 emissions. These monitors were located near ports or the coast. Analyses of emissions for these receptors indicated that the oceangoing vessel emissions did not play a large role in the emissions change from 2006 to 2020 and subsequently did not play a large role in 2020 projected design values. For seventy of these monitors, the 2005-2007 design values were already below 50 ppb and were often well below 50 ppb. This further indicated that oceangoing vessels may not play a large role in the monitor design values. For most monitors, the land-based emissions (point sources or other sources) were bigger contributors to monitor emissions. Even though the 2020 inventory did not contain the emissions associated with the ocean-going vessels, 2020 emissions were projected to decrease (EPA, 2009) and design values would decrease from 2006 to 2020.

Figure 3.7. 2006 12km gridded emissions (tons) and monitors (stars) located near coastal regions or ports.



3.3.3 Example monitors

This section describes the emissions changes for two monitors 99th percentile design values shown Figure 3.8. One monitor's design value, Tazewell County, IL decreased from 2005-2007 to 2020 (Figure 3.8a) and the other monitor's design value increased from 2005-2007 to 2020, Gila County, AZ (Figure 3.8b). Emissions in the 81 cell matrices for both monitors are shown in Table 3.5.

Figure 3.8. Locations of monitors in a) Tazewell County, IL and b) Gila County, AZ.

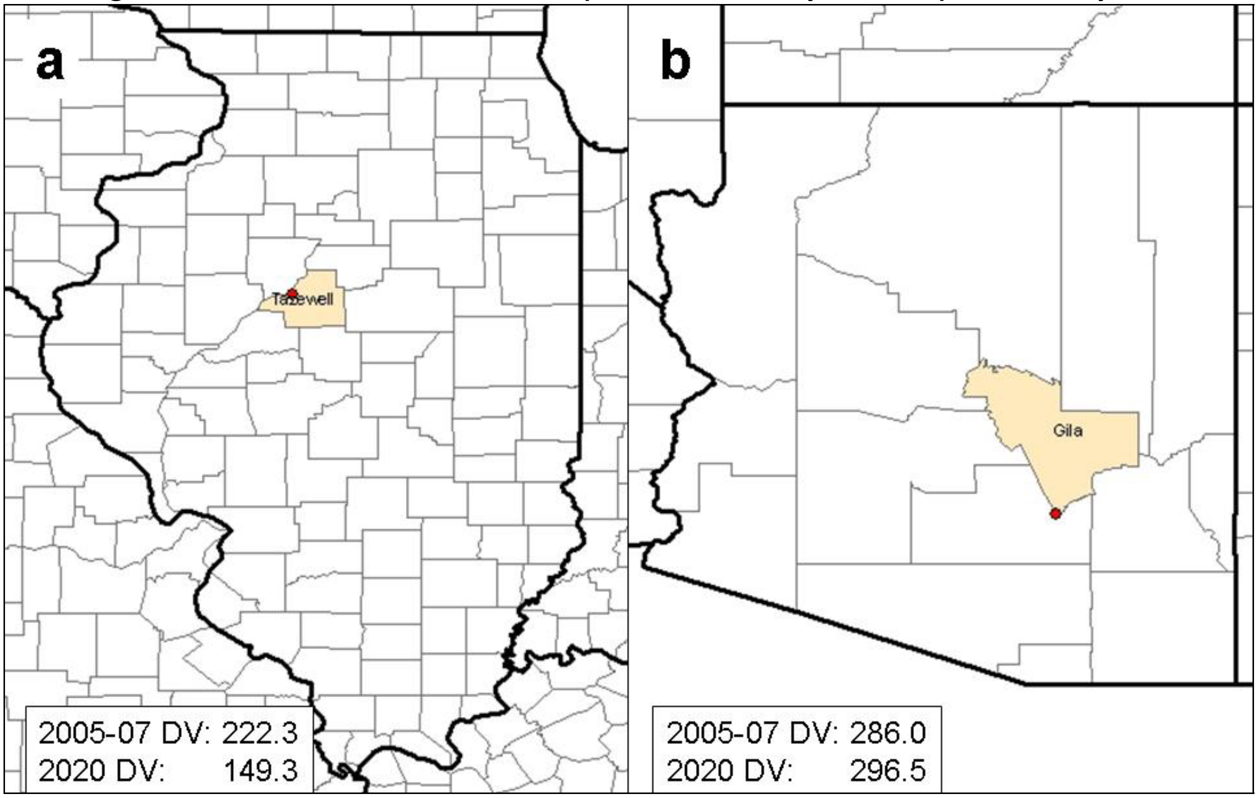


Table 3.5. 2006 and 2020 81-cell emissions for the monitors in Tazewell and Gila Counties by source sector.

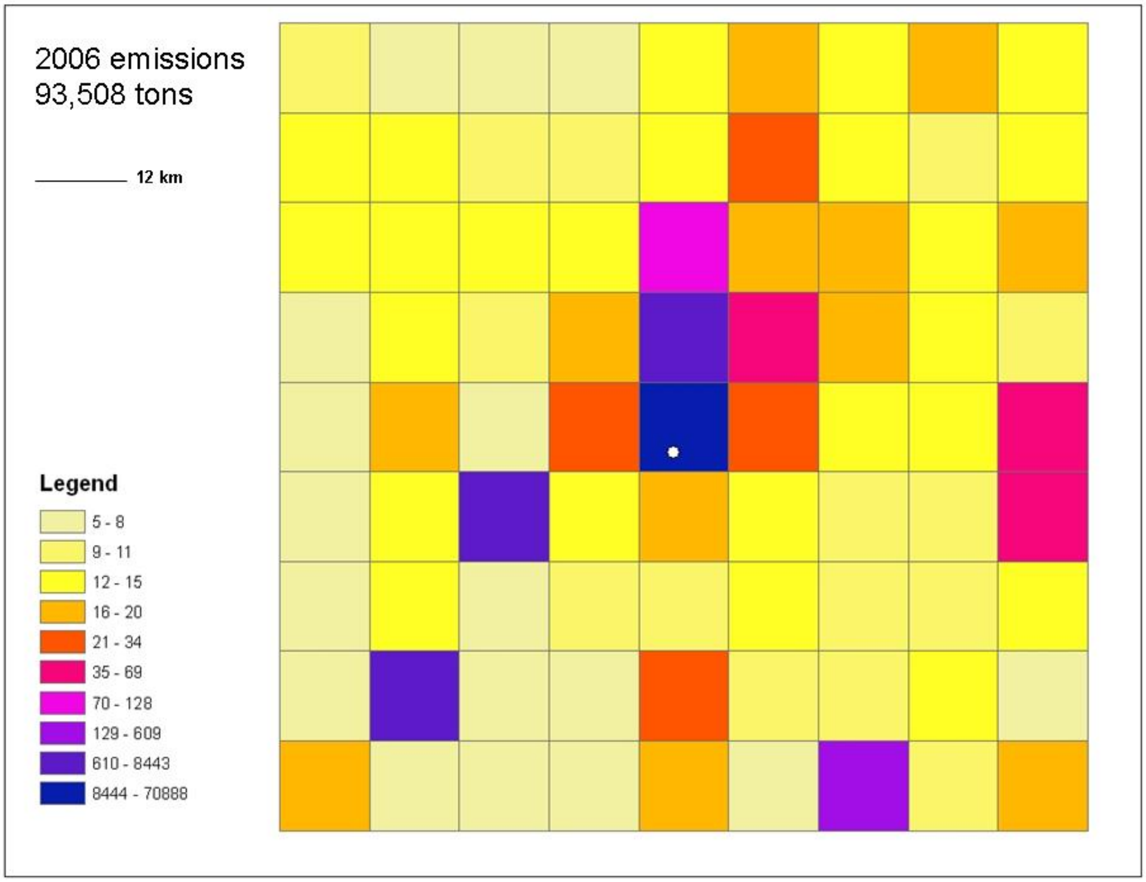
Emissions (tons)	Tazewell		Gila	
	2006	**2020**	**2006**	**2020**
EGU	70,714	38,386	0	0
Non-EGU	21,377	21,369	18,441	18,441
Other*	1,417	3,055	326	1,017
Total	93,508	62,810	18,767	19,458
Emissions ratio (2020/2006)	0.6717		1.0368	

*gridded nonpoint, nonroad, and onroad mobile emissions

3.3.2.1 Tazewell County

Gridded emissions are shown for the monitor in Tazewell County in Figure 3.9 for 2006 and Figure 3.10 for 2020. The overall matrix emissions decreased from 2006 to 2020 with the 2020 emissions being about 67% of the 2006 emissions. The grid cell containing the monitor (denoted by the white circle in Figures 3.9 and 3.10) was the highest emitting grid cell for 2006 in the emissions matrix with 70,888 tons of SO_2, approximately 75% of the matrix emissions (Figure 3.9). The grid cell was also the highest emitting grid cell for EGU point and non-EGU point sources, 58,357 and 12,458 tons respectively. The cell was the second highest, 74 tons, for other sources (excluding EGU and non-EGU point emissions) with the cell just north of it being the highest, 183 tons.

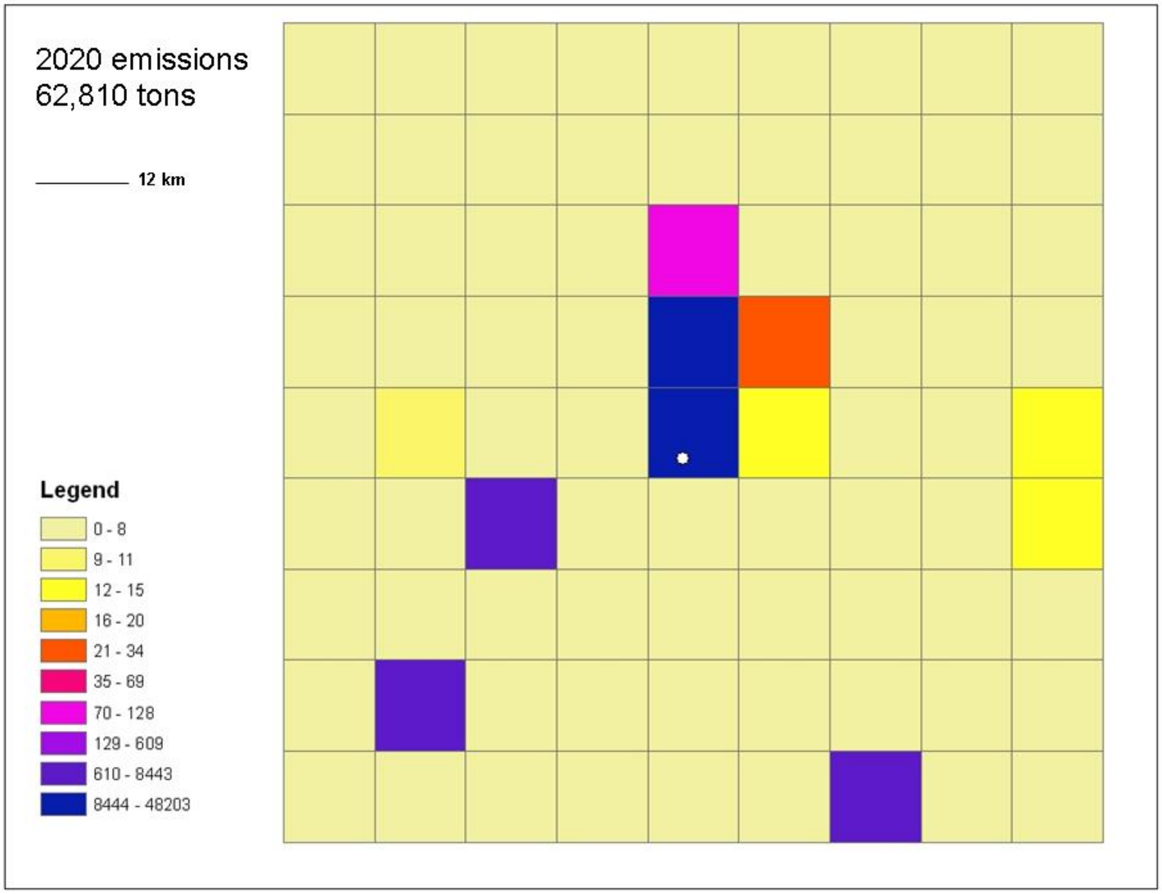
Figure 3.9. 2006 12 km grid cell SO_2 total emissions for Tazewell County monitor. The white dot represents the monitor location.



In 2020, the total matrix emissions were 62,810 tons with 48,203 in the monitor's home grid cell (Figure 3.10). As in 2006, the monitor's grid cell contains about 75% of the emissions and is the highest emitting grid cell for EGU point and non-EGU point, 33,610 and 12,458 tons respectively. The grid cell was also the highest emitting cell for other emissions, 2,135 tons.

The overall decrease in emissions was due to a decrease in EGU emissions between 2006 and 2020 with the monitor's grid cell being the dominant emission source. The decrease in emissions resulted in an emissions ratio of 0.67, which caused a concentration decrease from 222.3 to 149.6 ppb. This resulted in Tazewell County dropping from the third highest county in 2005-2007 to seventh highest in 2020.

Figure 3.10. 2020 12 km grid cell SO_2 total emissions for Tazewell County monitor. The white dot represents the monitor location.



3.3.2.2 Gila County

Gridded emissions for Gila County, AZ for 2006 and 2020 are shown in Figures 3.11 and 3.12 respectively. Emissions increased from 18,767 to 19,458 tons from 2006 to 2020. In 2006, the grid cell of the monitor contained 18,446 tons of SO_2 (98% of matrix total). The emissions were mostly non-EGU point sources, 18,438 tons (smelter activities), with seven tons from other sources. There were no EGU sources in the grid cell matrix for the monitor for either year. In 2020 the monitor's home grid cell contained 19,213 tons of SO_2 (98% of matrix total). The increase in emissions was due to an increase in other emissions (not EGU or non-EGU point) as the non-EGU emissions, for the grid cell and the matrix as a whole were relatively unchanged. The monitor's grid cell was the largest change in emissions. The increase in emissions resulted in an emissions ratio of 1.03 and an increase in design value concentrations from 286 to 296.5 ppb. Gila County remained the second highest county from 2005-2007 to 2020.

Figure 3.11. 2006 12 km grid cell SO_2 total emissions for Gila County monitor. The white dot represents the monitor location.

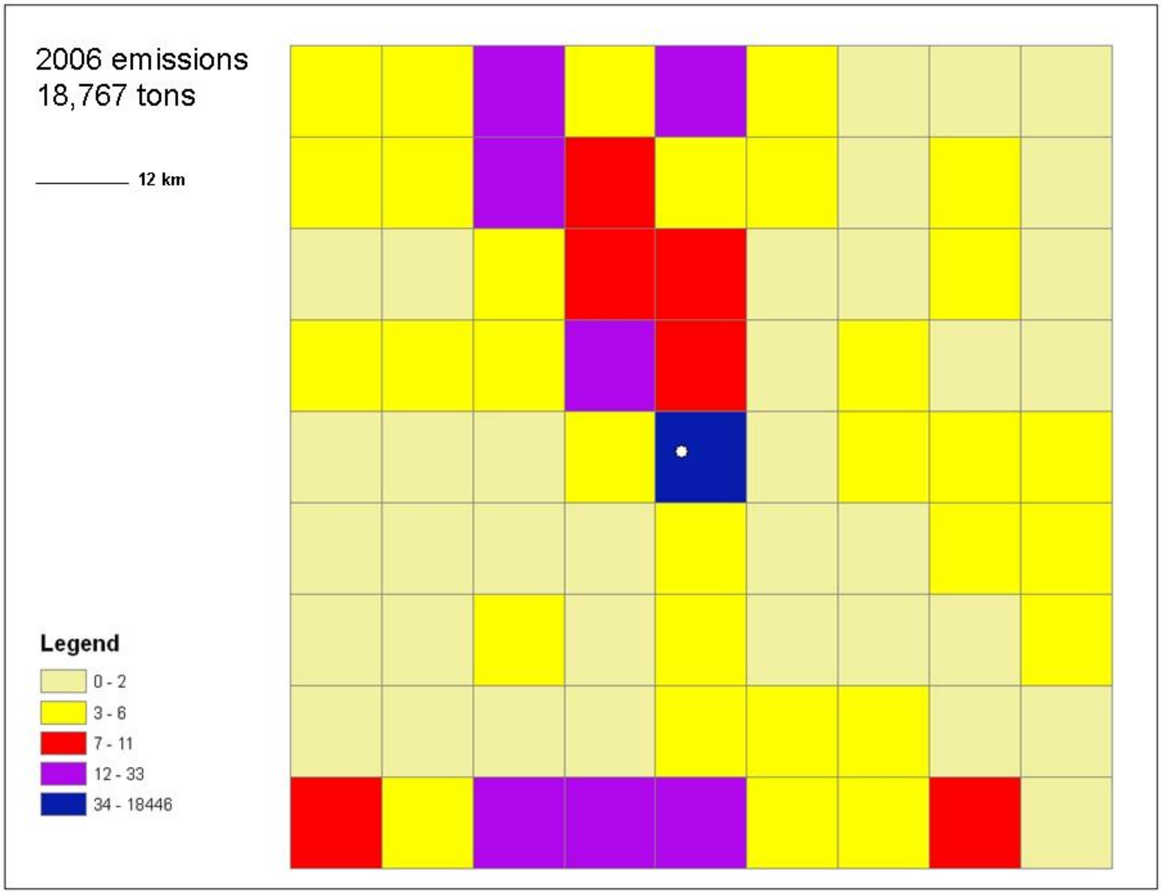
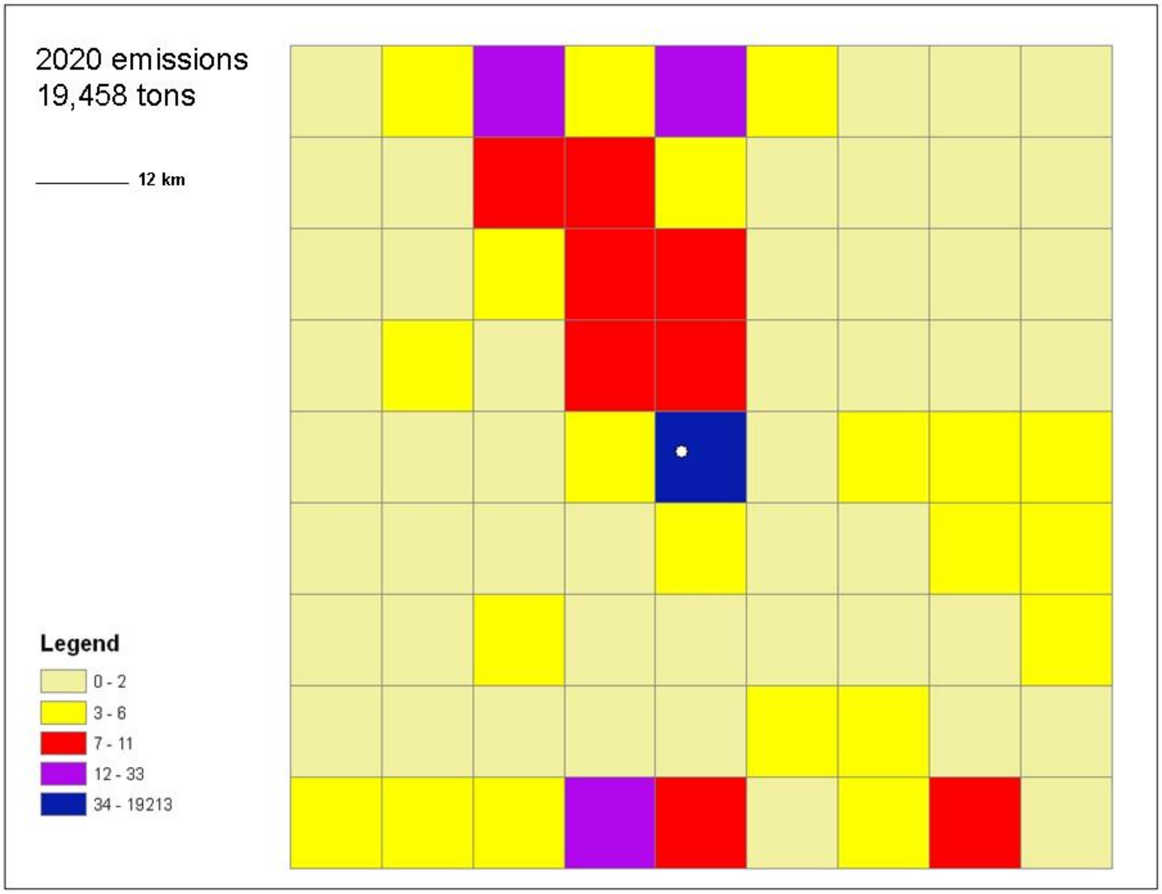


Figure 3.12. 2020 12 km grid cell SO_2 total emissions for Gila County monitor. The white dot represents the monitor location.



3.6 Summary

In summary, 2020 baseline NO_2 design value concentrations were projected from 2005-2007 observed design values using CMAQ emissions output from the 2006 and the 2020_070 scenario simulations performed for the ozone NAAQS RIA (U.S. EPA, 2008b). Results of the projections showed that, in 2020, nonattainment occurred for all four alternative standards (50, 75, 100, and 150 ppb). However, the number of counties exceeding the standards dropped from the 2005-2007 period.

3.7 References

Air Pollution from New Motor Vehicles: Tier 2 Motor Vehicle Emissions Standards and Gasoline Sulfur Control, U.S. Environmental Protection Agency, Office of Transportation and Air

Quality, Assessment and Standards Division, Ann Arbor, MI 48105, EPA420-R-99-023, December 1999. Available at http://www.epa.gov/tier2/frm/ria/r99023.pdf.

U.S. Environmental Protection Agency (EPA). 2000. *Regulatory Impact Analysis: Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements*, U.S. Environmental Protection Agency, Office of Transportation and Air Quality, Assessment and Standards Division, Ann Arbor, MI 48105, EPA420-R-00-026, December 2000. Available at http://www.epa.gov/otaq/highway-diesel/regs/exec-sum.pdf

U.S. Environmental Protection Agency (EPA). 2004. *Final Regulatory Analysis: Control of Emissions from Nonroad Diesel Engines*, U.S. Environmental Protection Agency, Office of Transportation and Air Quality, Assessment and Standards Division, Ann Arbor, MI 48105, EPA420-R-04-007, May 2004. Available at http://www.epa.gov/nonroaddiesel/2004fr/420r04007.pdf.

U.S. Environmental Protection Agency (EPA). 2005a. *Clean Air Interstate Rule Emissions Inventory Technical Support Document*, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, March 2005. Available at http://www.epa.gov/cair/pdfs/finaltech01.pdf.

U.S. Environmental Protection Agency (EPA). 2005b. *Emissions Inventory and Emissions Processing for the Clean Air Mercury Rule (CAMR),* U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, March 2005. Available at http://www.epa.gov/ttn/atw/utility/emiss_inv_oar-2002-0056-6129.pdf

U.S. Environmental Protection Agency (EPA). 2005c. *Regulatory Impact Analysis for the Final Clean Air Visibility Rule or the Guidelines for Best Available Retrofit Technology (BART) Determinations Under the Regional Haze Regulations,* U.S. Environmental Protection Agency, Office of Air and Radiation, June 2005. EPA-452-R-05-004. Available at http://www.epa.gov/visibility/pdfs/bart_ria_2005_6_15.pdf

U.S. Environmental Protection Agency (EPA). 2007a. *Regulatory Announcement: EPA Proposal for More Stringent Emissions Standards for Locomotives and Marine Compression-Ignition Engines*. EPA420-F-07-015.

U.S. Environmental Protection Agency (EPA). 2007b, *Proposed Emission Standards for New Nonroad Spark-Ignition Engines, Equipment, and Vessels*. EPA420-F-07-032.

U.S. Environmental Protection Agency (EPA). 2008a. *Air Quality Modeling Platform for the Ozone National Ambient Air Quality Standard Final Rule Regulatory Impact Analysis*. North Carolina. EPA-454/R-08-003.

U.S. Environmental Protection Agency (EPA). 2008b. *Final Ozone NAAQS Regulatory Impact Analysis*. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, March 2005. EPA-452/R-08-003.

U.S. Environmental Protection Agency (EPA). 2009. *Control of Emissions from New Marine Compression-ignition Engines at or above 30 Liters per Cylinder; Proposed Rule.* 40 CFR Parts 80,85, 86, et al.